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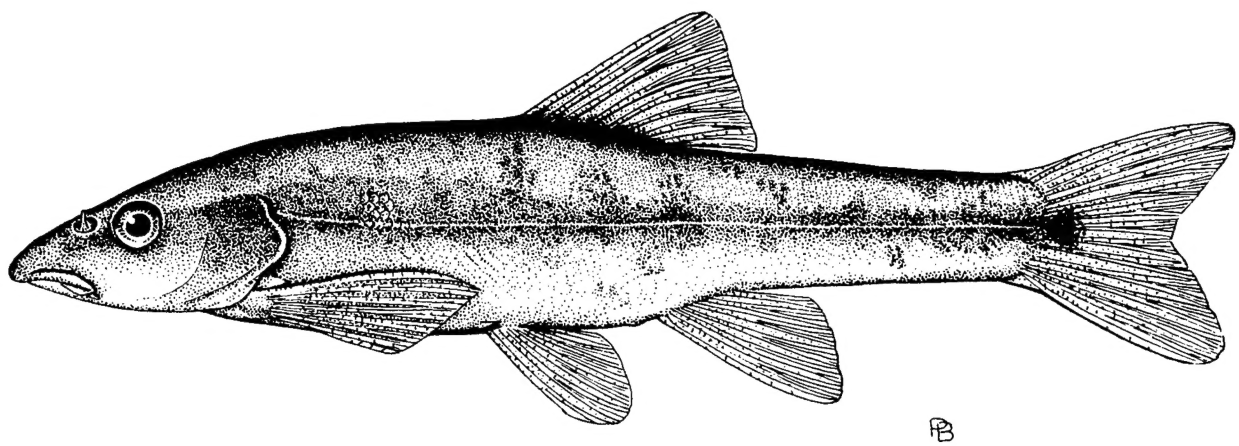
HABITAT SUITABILITY INDEX MODELS: LONGNOSE DACE



Fish and Wildlife Service

U.S. Department of the Interior

This model is designed to be used by the Division of Ecological Services in conjunction with the Habitat Evaluation Procedures.

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HABITAT SUITABILITY INDEX MODELS: LONGNOSE DACE

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PREFACE

The habitat use information and Habitat Suitability Index (HSI) models presented in this document are an aid for impact assessment and habitat management activities. Literature concerning a species' habitat requirements and preferences is reviewed and then synthesized into subjective HSI models, which are scaled to produce an index between 0 (unsuitable habitat) and 1 (optimal habitat). Assumptions used to transform habitat use information into these mathematical models are noted, and guidelines for model application are described. Preference curves for use with the Instream Flow Incremental Methodology (IFIM) are excluded from this publication. A summary document describing curves for use with IFIM for this species and preceding species publications in this series (82/10) is planned for early 1984.

Use of the models presented in this publication for impact assessment requires the setting of clear study objectives and may require modification of the models to meet those objectives. Methods for modifying HSI models and recommended measurement techniques for model variables are presented in Terrell et al. (1982).[1] A discussion of HSI model building techniques is presented in U.S. Fish and Wildlife Service (1981).[2]

The HSI models presented herein are complex hypotheses of species-habitat relationships, not statements of proven cause and effect relationships. The models have not been tested against field population data. For this reason, the U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help us increase the utility and effectiveness of the use of HSI models for fish and wildlife planning. Please send comments to:

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[1]Terrell, J. W., T. E. McMahon, P. D. Inskip, R. F. Raleigh, and K. L. Williamson. 1982. Habitat suitability index models: Appendix A. Guidelines for riverine and lacustrine applications of fish HSI models with the Habitat Evaluation Procedures. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.A. 54 pp.

[2]U.S. Fish and Wildlife Service. 1981. Standards for the development of habitat suitability index models. 103 ESM. U.S. Dept. Int., Fish Wildl. Serv., Div. Ecol. Serv. n.p.

CONTENTS

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LONGNOSE DACE (*Rhinichthys cataractae*)

HABITAT USE INFORMATION

General

The longnose dace (*Rhinichthys cataractae*) occurs from coast to coast across North America as far south as the Rocky Mountains in Mexico and as far north as the MacKenzie River near the Arctic Circle (Bartnik 1972; Lee et al. 1980). The species is more ubiquitous on the Atlantic slope, where it extends south through the Appalachians to Georgia, than in the West, where it extends along the Rocky Mountains and throughout the Pacific slope from Oregon north through British Columbia, including the Columbia River drainage (McPhail and Lindsey 1970; Lee et al. 1980).

Age, Growth, and Food

Longnose dace are mature at age II (McPhail and Lindsey 1970; Gibbons and Gee 1972; Brazo et al. 1978). The oldest reported individual of this species was V years old (Kuehn 1949; Sigler and Miller 1963; Reed and Moulton 1973). Adults are usually about 6.3 to 8.8 cm in length (Sigler and Miller 1963), but lengths up to 14.1 cm for females and 12.9 cm for males have been reported (Kuehn 1949; Reed 1959; Reed and Moulton 1973; Brazo et al. 1978). Brazo et al. (1978) found that the Lake Michigan population grew larger than stream populations but rarely lived over IV years.

Longnose dace are well-adapted for feeding on the bottom (Anderson and Brazo 1978) and will eat whatever is abundant (Gerald 1966). Riverine populations feed mainly on Chironomidae (Diptera), Ephemeridae (Ephemeroptera), and Simulidae (Diptera), although they will feed on other aquatic insects (Kuehn 1949; Gerald 1966; Gibbons and Gee 1972). Fry eat algae and, as they grow, they eat mayflies and chironomids. Juveniles eat mainly mayflies and chironomids, while adults add simulids, primarily a riffle-dwelling dipteran, to their diet (Kuehn 1949; Gerald 1966). Lacustrine longnose dace populations feed primarily on terrestrial insects that have been washed into the surge zone from the beach (Brazo et al. 1978). Lacustrine dwelling fry eat algae, diatoms, zooplankton, and fish scales. At the end of the first growing season, both juveniles and adults eat chironomids, fish eggs, annelids, and other aquatic insects, as well as terrestrial insects (Anderson and Brazo 1978; Brazo et al. 1978).

Reproduction

Longnose dace select and defend territories during the breeding season (Bartnik 1973). The peak of longnose dace spawning usually occurs in June to early July in both lakes and streams (McPhail and Lindsey 1970; Gee and Machniak 1972; Brazo et al. 1978). Spawning may occur as early as May (Maryland) (Carlander 1959) and as late as August (Alberta), depending on water temperature (McPhail and Lindsey 1970). In Lake Winnipeg, Canada, spawning was 5 to 7 weeks later than in the streams, probably due to lower water temperatures in the lake (Gee and Machniak 1972).

Spawning occurs when the daily maximum temperature exceeds 15° C (Bartnik 1970). In Lake Michigan, longnose dace began to come into shore at 8 to 14° C and peak spawning occurred at 14 to 19° C (Brazo et al. 1978). In Montana, spawning occurred at 11.7° C (Brown 1971).

In streams, longnose dace spawn only in riffles with a velocity of 45 to 60 cm/sec (Bartnik 1970). In lakes, the species spawns in wave-swept inshore areas (Brazo et al. 1978). Spawning is restricted to places where the substrate is coarse enough to provide natural depressions in the substrate for egg deposition (Bartnik 1970, 1973). The substrate in streams is usually gravel and rock with an upper limit of 5 to 20 cm in diameter (Bartnik 1970; Brazo et al. 1978). Overhead cover and shelter from the current is always present (Bartnik 1973). On the inshore area of Lake Winnipeg, spawning dace were observed only over a substrate consisting of 100% large rocks (8 to 30 cm in diameter) (Gee and Machniak 1972).

Specific Habitat Requirements

Longnose dace are most abundant in swift flowing, steep gradient, headwater streams of larger river systems (Kuehn 1949; Reed 1959; Reed and Moulton 1973; Merritt et al. 1978). The stream habitat is usually boulder-strewn, with gravel and rock beds (Smith 1979), and may be classified as a "trout stream" (Kuehn 1949; Reed 1959). According to the stream order classification system described by Kuehne (1962), longnose dace probably live in streams with gradients from 1.9 to 18.7 m/km. The species occasionally lives in the nearshore, turbulent waters of lakes and occurs in all of the Great Lakes (Anderson and Brazo 1978; Brazo et al. 1978).

All age groups of longnose dace occur in very shallow water, usually < 0.3 m deep (Gee and Northcote 1963) and rarely > 1 m deep (Sigler and Miller 1963). Overhead cover and shelter from the current is required during all seasons (Bartnik 1973). Longnose dace are usually collected in streams with a current velocity > 45 cm/sec (Gee and Northcote 1963).

Specific turbidity tolerance limits are unknown, but the species tolerates waters that are temporarily turbid, murky, or muddy (Sigler and Miller 1963; McPhail and Lindsey 1970). Longnose dace also live in swift turbid streams of the upper Great Plains (Lee et al. 1980). Lake forms generally occur in more turbid waters than stream forms (Smith 1979).

Adult. Adult longnose dace are more or less benthic and inhabit the region directly above the substrate (McPhail and Lindsey 1970). They prefer riffle areas in streams but will occupy quiet, shallow water pools in the absence of competing species, especially during the summer (Gee and Northcote 1963; Bartnik 1970; Gibbons and Gee 1972; Reed and Moulton 1973). Adults usually live in the protection of crannies between stones in very fast water (McPhail and Lindsey 1970). They are most abundant in waters with a current > 45 cm/sec (Bartnik 1970) and will live in areas with surface velocity as high as 182 cm/sec (McPhail and Lindsey 1970). In Lake Winnipeg, adults were thought to occur in the deep channels between islands where the current was swift (Gee and Machniak 1972). Longnose dace swimming against strong currents for even short periods (5 minutes) become fatigued and lose their ability for coordinated locomotion; shelter from the current must be present (Bartnik 1973).

In Utah, longnose dace have been reported to inhabit streams with maximum temperatures of 12.8 to 21.1° C (Sigler and Miller 1963). Brazo (personal communication) has collected longnose dace at water temperatures from 5.4-22.7° C.

Embryo. The eggs of longnose dace are demersal and adhesive and are deposited in natural depressions (McPhail and Lindsey 1970). Optimum spawning temperatures range from 14 to 19° C (Brazo et al. 1978). Incubation takes from 7 to 10 days at 15.6° C (McPhail and Lindsey 1970). The yolk sac is absorbed in about 7 days after hatching (McPhail and Lindsey 1970).

Fry. In both lakes and streams, fry become pelagic and are abundant in the protected margins of quiet shallow water (Reed 1959; Gee and Northcote 1963; Gee and Machniak 1972; Gibbons and Gee 1972). In lakes, fry were close to shore under cover of overhanging vegetation (Gee and Machniak 1972) and over gravel and small stones ≤ 5.0 cm in diameter (Lake Michigan) (Brazo et al. 1978).

Fry inflate their swimbladder by gulping air, becoming pelagic (Gee and Machniak 1972). They adjust their buoyancy by altering the swimbladder volume in response to wave action in lakes or changes in current velocity in streams (Gee 1968, 1972, 1974). However, as the fish grows, the extent of adjustment is reduced and occurs over a lower range of buoyancy values. Within 6 weeks, the young begin to move to areas of swift water (Gee and Machniak 1972; Gibbons and Gee 1972). By the time the fish are 30 mm TL, they have moved to swift water areas in streams with a velocity > 45 cm/sec (Bartnik 1970). In lakes, longnose dace move to deeper water with a swift current by the time they are 30 mm TL (Gee and Machniak 1972).

Fry show a preference for areas with overhead cover (Bartnik 1973).

Juvenile. In general, juvenile habitat requirements are similar to those for adults. In streams, juvenile longnose dace are in riffle areas with a velocity > 45 cm/sec but will seek out the quieter areas (Gibbons and Gee 1972).

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area. The models are applicable in lakes and streams throughout North America.

Season. The model provides a rating for a water body based on its ability to support a reproducing population of longnose dace through all seasons of the year. The model will provide an HSI of 0 if any reproduction-related variable indicates that the species is not able to reproduce in the habitat being evaluated.

Cover types. The model is applicable to riverine and lacustrine habitats, as described by Cowardin et al. (1979).

Minimum habitat area. No attempt has been made to establish a minimum habitat size for longnose dace. However, lakes must be large enough to produce wave action on the shore, and streams must have ample shallow water and riffle areas.

Verification level. The acceptance goal of the model is to produce an index between 0 and 1 that has a positive relationship to the ability of longnose dace to live and reproduce in an area. In order to verify that the model output was acceptable, HSI's were calculated from sample data sets. These sample data sets and their relationship to model verification are discussed in greater detail following the presentation of the model.

Model Description - Riverine

The analysis of longnose dace habitat quality is based on key variables that are important to the existence of the species in a particular habitat (Figs. 1 and 2). Almost all of the variables are directly related to the species' ability to reproduce in an area and are not compensatory. Each variable is important enough to the survival and growth of longnose dace that I believe suboptimum levels will be limiting no matter how high the suitability ratings are for the other variables.

Average current velocity (V_1) is an important variable since longnose dace are usually collected in streams with a high velocity and are adapted to high velocity areas. Percent riffles (V_3) is included because the species lives primarily in riffle areas of streams. They will spawn only in riffles. Percent cover and shelter (V_6) is included because longnose dace require overhead cover and shelter from current in high velocity areas where they live.

Maximum depth of riffle or nearshore area (V_2) is included because the species lives and spawns in shallow water. Spawning will not take place unless the substrate type (V_4) is coarse enough to provide interstitial spaces for the eggs. Successful longnose dace spawning is limited to a substrate with gravel and rocks of suitable size.

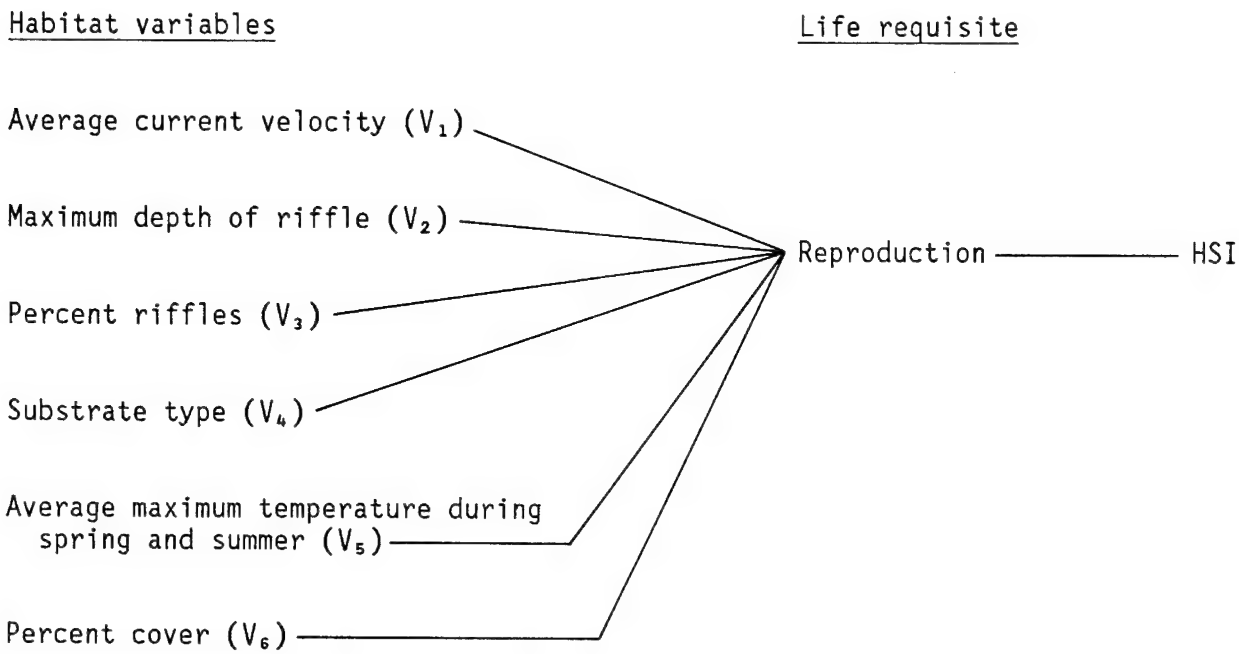


Figure 1. Habitat variables included in the riverine model for longnose dace.

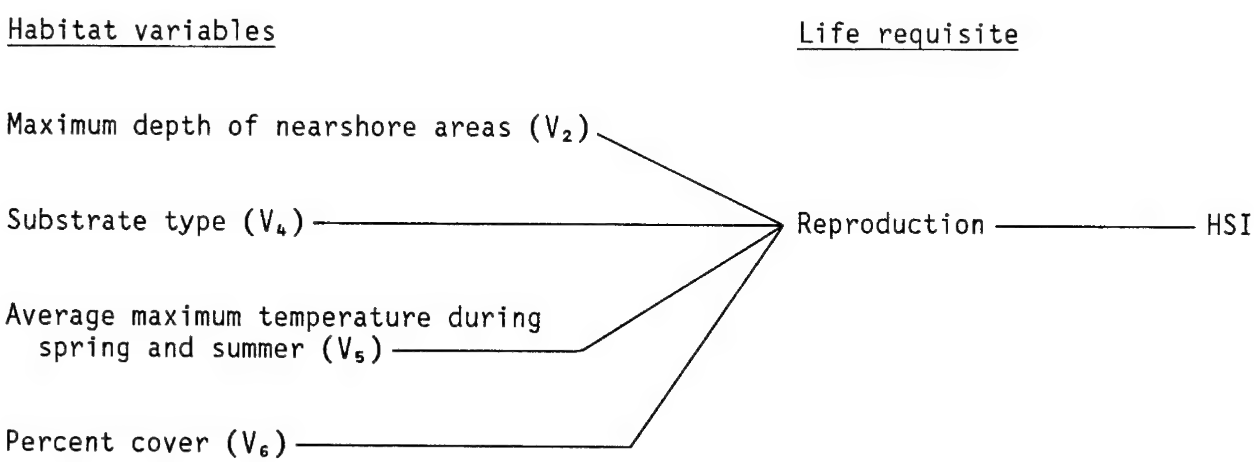


Figure 2. Habitat variables included in the lacustrine model for longnose dace.

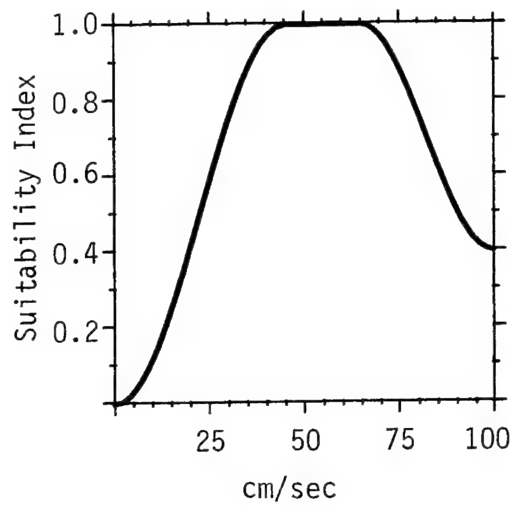
Temperature (V_5) is the most important water quality factor limiting longnose dace because it affects the survival of all life stages.

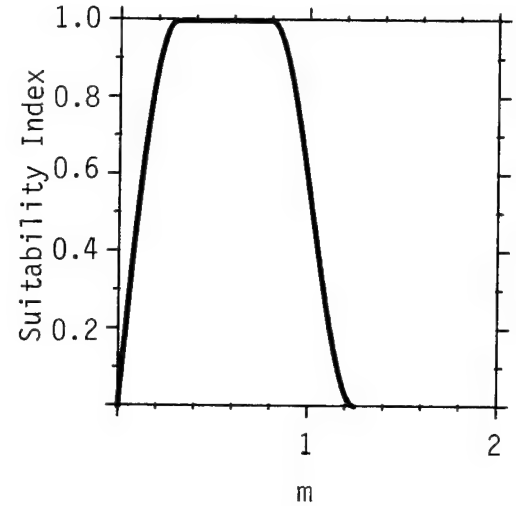
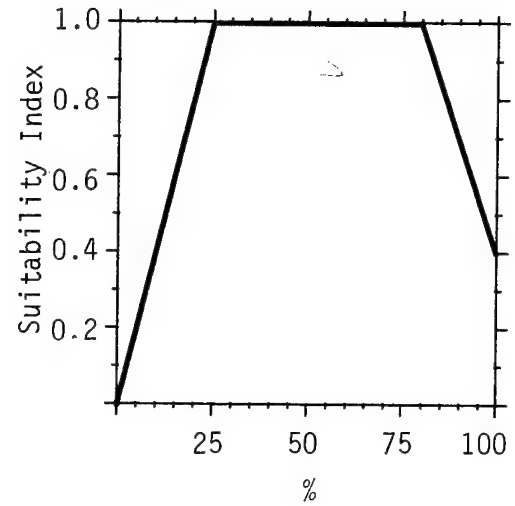
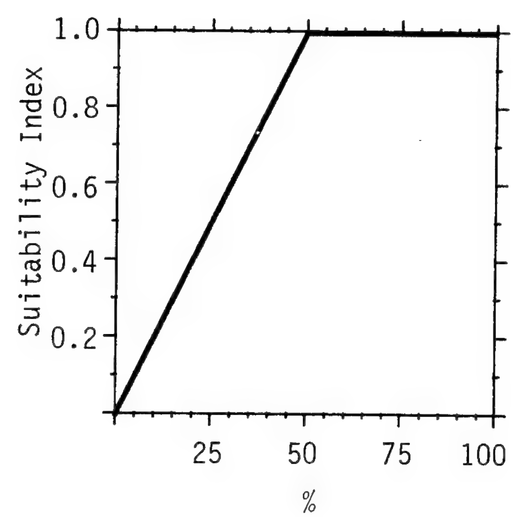
Model Description - Lacustrine

The variables in the lacustrine model for longnose dace are also in the riverine model. These variables include maximum depth of nearshore areas (V_2), substrate type (V_4), maximum water temperature during spring and summer (V_5), and percent cover and shelter (V_6). See Model Description - Riverine.

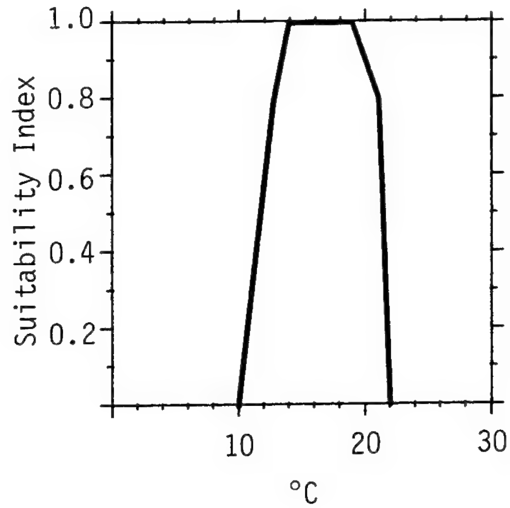
Suitability Index (SI) Graphs for Model Variables

This section contains suitability index graphs for the six variables described above and equations for combining variable indices into a species HSI using the limiting factor approach. Variables may pertain to either a riverine (R) habitat, a lacustrine (L) habitat, or both.

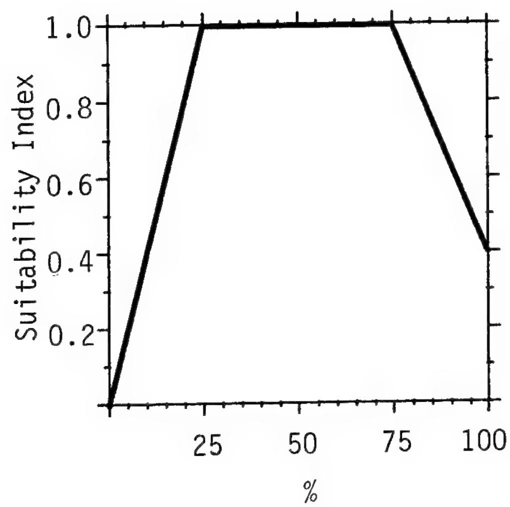
Habitat	Variable		Suitability graph
R	V_1	Average current velocity during spring and summer.	

R,L	V_2	Maximum depth of riffle (R) or nearshore area (L).	
R	V_3	Percent riffles in sample area.	
R,L	V_4	Percent stream or shore area with gravel and rock substrate with a diameter limit of at least 5-20 cm in streams and 8-30 cm in lakes.	

R,L V_5 Average maximum temperature during spring and summer in riffle and nearshore areas (adult, juvenile, fry, and embryo).



R,L V_6 Percent cover and shelter from the current in the form of boulders, large rocks, logs, and/or debris.



Riverine Model

The following equation utilizes the limiting factor approach. All of the variables are important to the existence and ability to reproduce of longnose dace in a particular habitat.

$$HSI = \text{lowest of } V_1, V_2, V_3, V_4, V_5, \text{ or } V_6$$

Lacustrine Model

This model utilizes the limiting factor approach. All of the variables are important to the existence and reproductive ability of longnose dace in a particular habitat.

$$HSI = \text{lowest of } V_2,\ V_4,\ V_5, \text{ or } V_6$$

Sources of data and assumptions made in developing the suitability indices are presented in Table 1.

Sample data sets from which HSI's have been generated using the riverine HSI equation are in Table 2. Similar data sets using the lacustrine HSI equation are in Table 3. The data sets are not actual field measurements, but represent combinations of conditions that could occur in a riverine or lacustrine habitat. We believe that the HSI's calculated from the data reflect what carrying capacity trends would be in riverine and lacustrine habitats with the listed characteristics.

Interpreting Model Outputs

Habitats with an HSI of 0 may contain some longnose dace; habitats with a high HSI may contain few. The longnose dace HSI determined by use of these models will not necessarily represent the population of longnose dace in the study area. Standing crop estimates may not reflect habitat suitability at the location and single point in time where the estimate was made. Fish may be captured during a migratory phase when they are passing through habitats of various qualities. In addition, only physical habitat parameters and temperature are included in the model. Biotic factors can change the nature of the relationships presented in the model. In areas where longnose dace population levels are due primarily to habitat-related factors, the model should be positively correlated with long term average population levels. However, this has not been tested. The proper interpretation of the HSI is one of comparison. If two habitats have different HSI's, the one with the higher HSI should have a greater potential to support longnose dace than the one with the lower HSI, given that the model assumptions have not been violated.

Table 1. Data sources and assumptions for longnose dace suitability indices.

Variable and source		Assumption
V_1	Gee and Northcote 1963 Bartnik 1970 McPhail and Lindsey 1970	Current velocities where longnose dace are most common are optimum.
V_2	Gee and Northcote 1963 Sigler and Miller 1963	The depth where longnose dace are most abundant is optimum.
V_3	Gee and Northcote 1963 Bartnik 1970 Gibbons and Gee 1972 Reed and Moulton 1973	The percentage of riffles where longnose dace are most successful is optimum.
V_4	Bartnik 1970 McPhail and Lindsey 1970 Gee and Machniak 1972 Brazo et al. 1978 Smith 1979	The percentage of substrate where spawning is most successful is optimum.
V_5	Koster 1957 Sigler and Miller 1963	Temperatures where longnose dace are most abundant are optimum.
V_6	Bartnik 1973	Because longnose dace have strong cover and shelter-seeking behavior during all seasons of the year, overhead cover and shelter from the current must be present in adequate amounts for habitat to be suitable.

Table 2. Sample data sets using the riverine HSI model.

Variable		Data set 1 Data	SI	Data set 2 Data	SI	Data set 3 Data	SI
Current velocity (cm/sec)	V_1	55	1.0	15	0.2	45	1.0
Depth (m)	V_2	0.4	1.0	3	0	0.5	1.0
Riffles (%)	V_3	35	1.0	30	1.0	50	1.0
Substrate type	V_4	100	1.0	25	0.5	20	0.4
Temperature (°C)	V_5	16	1.0	23	0	15	1.0
Cover and shelter (%)	V_6	50	1.0	25	1.0	25	1.0
HSI =			1.0		0		0.4

Table 3. Sample data sets using lacustrine HSI model.

Variable		Data set 1 Data	SI	Data set 2 Data	SI	Data set 3 Data	SI
Depth (m)	V_2	0.4	1.0	3	0	0.5	1.0
Substrate type	V_4	100	1.0	25	0.5	50	1.0
Temperature (°C)	V_5	16	1.0	15	1.0	12.8	0.8
Cover and shelter (%)	V_6	50	1.0	50	1.0	50	1.0
HSI =			1.0		0		0.8

REFERENCES

Anderson, R. C., and D. Brazo. 1978. Abundance, feeding habits, and degree of segregation of the spottail shiner (Notropis hudsonicus) and longnose dace (Rhinichthys cataractae), in Lake Michigan surge-zone near Ludington, Michigan. Mich. Acad. 10(3):337-346.

Bartnik, V. G. 1970. Reproductive isolation between two sympatric dace, Rhinichthys atratulus and R. cataractae, in Manitoba. J. Fish. Res. Board Can. 27:2125-2141.

____________. 1972. Comparison of the breeding habits of two subspecies of longnose dace, Rhinichthys cataractae. Can. J. Zool. 50:83-86.

____________. 1973. Behavioral ecology of the longnose dace, Rhinichythys cataractae (Pices, Cyprinidae), significance of the dace social organization. Ph.D. Thesis, Dept. Zoology, Univ. British Columbia. 163 pp.

Brazo, D. C. 1982. Personal communication. Michigan State Univ., East Lansing, Michigan.

Brazo, D. C., C. R. Liston, and R. C. Anderson. 1978. Life history of the longnose dace, Rhinichthys cataractae, in the surge zone of eastern Lake Michigan near Ludington, Michigan. Trans. Am. Fish. Soc. 107:550-556.

Brown, C. J. D. 1971. Fishes of Montana. Big Sky Books, Bozeman, MT. 207 pp.

Cowardin, L. M., V. Carter, F. C. Golet, and E. J. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-79/31. 103 pp.

Gee, J. H. 1968. Adjustment of buoyancy by longnose dace (Rhinichthys cataractae) in relation to water velocity. J. Fish. Res. Board Can. 25:1485-1496.

____________. 1972. Adaptive variation in swimbladder length and volume in dace, genus Rhinichthys. J. Fish. Res. Board Can. 29:119-127.

____________. 1974. Behavioral and developmental plasticity of buoyancy in the longnose, Rhinichthys cataractae (Cyprinidae), dace. J. Fish. Res. Board Can. 31:35-41.

Gee, J. H., and K. Machniak. 1972. Ecological notes on a lake-dwelling population of longnose dace (Rhinichthys cataractae). J. Fish. Res. Board Can. 29:330-332.

Gee, J. H., and T. G. Northcote. 1963. Comparative ecology of two sympatric species of dace (Rhinichthys) in the Fraser River system, British Columbia. J. Fish. Res. Board Can. 20:105-118.

Gerald, J. W. 1966. Food habits of the longnose dace, Rhinichthys cataractae. Copeia 1966:478-485.

Gibbons, J. R. H., and J. H. Gee. 1972. Ecological segregation between longnose and blacknose dace (genus Rhinichthys) in the Mink River, Manitoba. J. Fish. Res. Board Can. 29:1245-1252.

Kuehn, J. H. 1949. A study of a population of longnose dace (Rhinichthys cataractae). Proc. of the Minn. Acad. Sci. 17:81-87.

Kuehne, R. A. 1962. A classification of streams, illustrated by fish distribution in an eastern Kentucky creek. Ecology 43(4):608-614.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Biological Survey Publ. 1980-12. 854 pp.

McPhail, J. D., and C. C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Board Can. 173. 381 pp.

Reed, R. J. 1959. Age, growth, and food of the longnose dace, Rhinichthys cataractae, in northwestern Pennsylvania. Copeia 1959:160-162.

Reed, R. J., and J. C. Moulton. 1973. Age and growth of blacknose dace, Rhinichthys atratulus, and longnose dace, R. cataractae, in Massachusetts. Am. Midl. Nat. 90:206-210.

Sigler, W. F., and R. R. Miller. 1963. Fishes of Utah. Utah State Dept. Fish and Game, Salt Lake City. 203 pp.

Smith, P. W. 1979. The fishes of Illinois. Ill. Nat. Hist. Surv., Univ. Ill. Press, Urbana. 314 pp.

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

A review and synthesis of existing information was used to develop riverine and lacustrine habitat models for longnose dace, (*Rhinichthys cataractae*) a freshwater species. The models are scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for freshwater, marine and estuarine areas of the continental United States. Habitat suitability indexes are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

Mathematical models, Fishes, Estuaries, Aquatic biology, Habitability.

b. Identifiers/Open-Ended Terms

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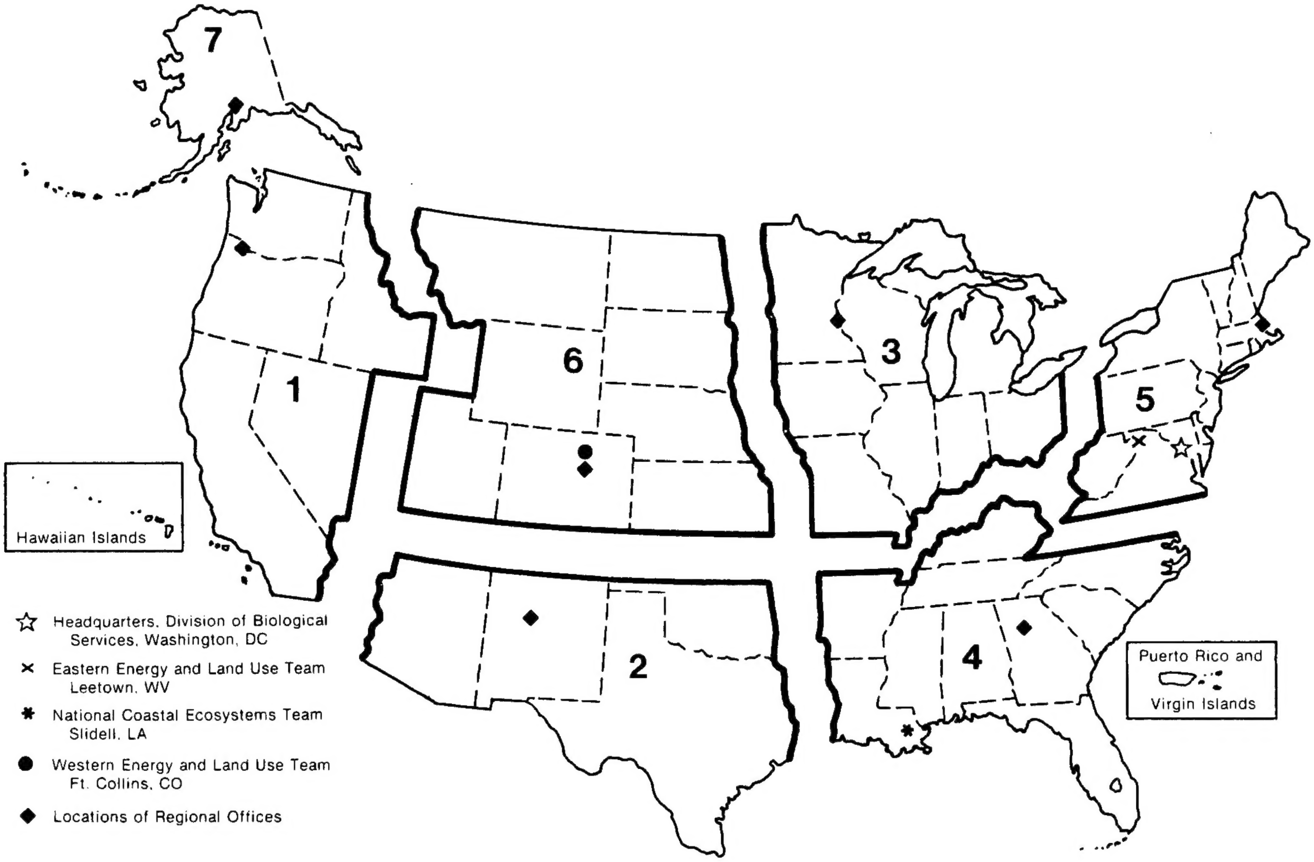

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Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REGION 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.